The Use of Model-Driven Methodologies and Processes in Aegis Development

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Open Architecture Evolution

Phase 1: Commercial Technology…

- ***Commercial Standards***
- ***Commodity Products***
- ***Separation of Application/ Infrastructure***
- ***Planned Refresh Cycles***

Leverage the Commercial Marketplace – Exploit Continuous Increases in Performance

Open Architecture Evolution

Phase 2: Componentized Software…

- ***Component-Based Designs***
- ***Distributed Processing***
- ***Message-Passing Architectures***
- ***Modern Development Technologies***

Decreased Development Time – Reduced Cost

Open Architecture Evolution

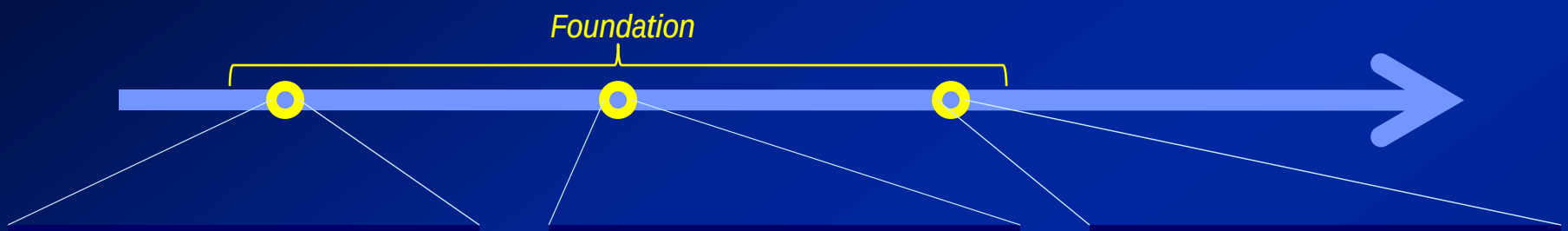
Phase 3: Open Business Model…

- ***Open Disclosure / Data Rights***
- ***Peer Reviews and Independent Assessments***
- ***OAET – Contract Guidebook***
- ***SHARE Repository***
- ***Industry Days***
- ***Technology Collaboration Centers***

Increased Number of Players/Opportunities – Improved Transition of S&T Into Fleet

Open Architecture Evolution

Step-by-Step…



- ***Commercial Standards***
- ***Commodity Products***
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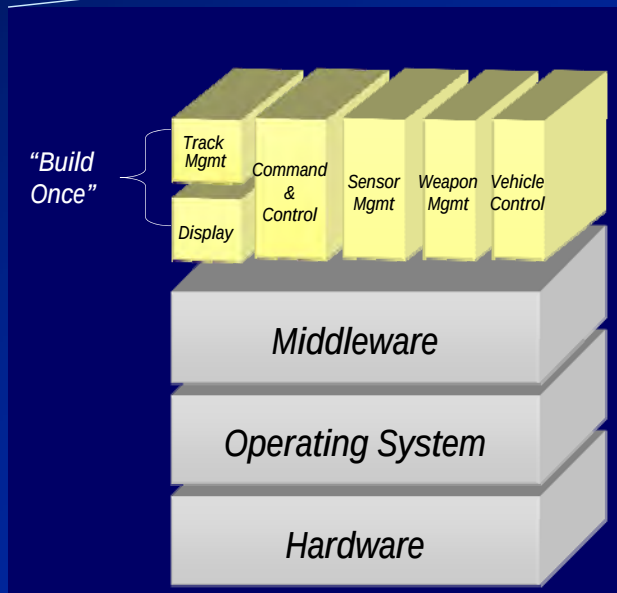
Maximizing Affordability

Open Architecture Evolution

Combat System Alignment…



- ***Product-Line Approach***
- ***Decouple Capability Development from Platform***
- ***Government Owned Architecture and Authenticated Interfaces***
- ***High-Level Acquisition Strategy***
- ***Objective Architecture***

Reuse Capability Improvements – "Build it Once"

Objective Architecture

Roles and Responsibilities…

Government

Combat System Architect

- ***Objective Architecture***
- ***Common Data Model and Messages***
- ***Common Component Interfaces***

Contractor

Platform System Engineering Agent

- ***System Engineering and Integration of GFE Capabilities***
- ***Support Peer Reviews***
- ***End-to-End System Performance***

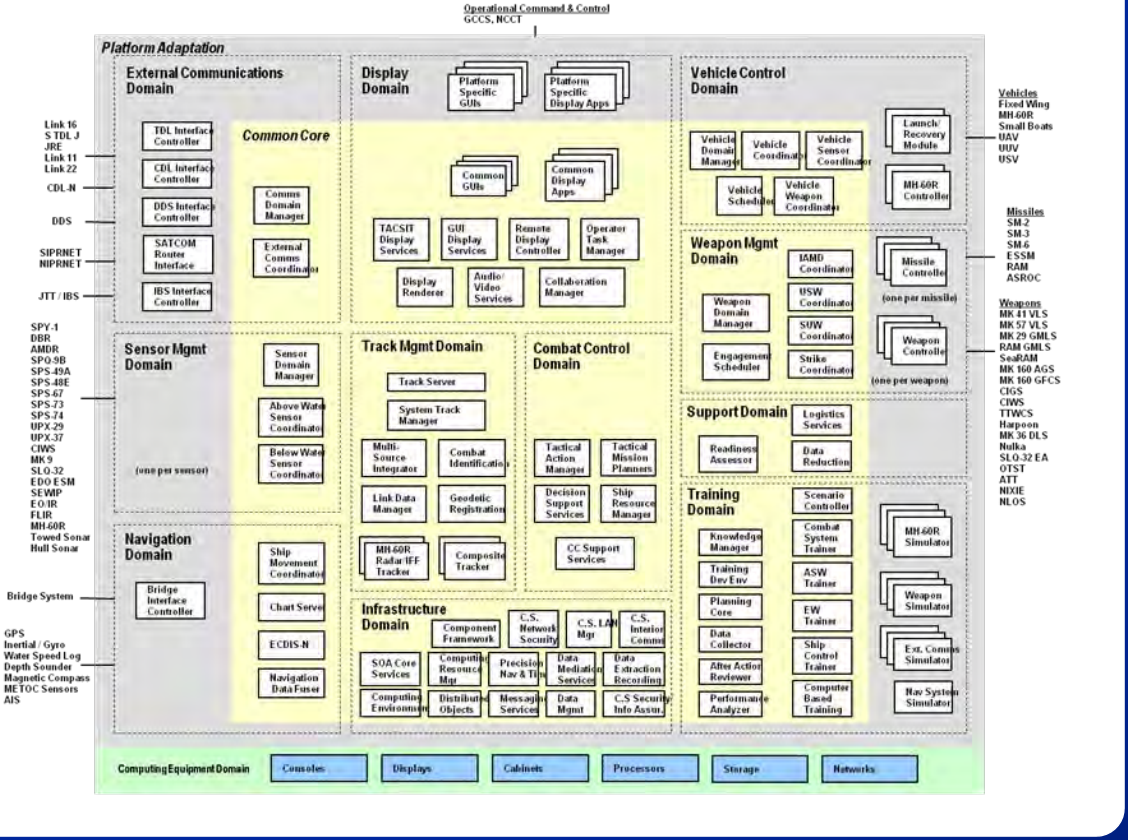
Developer

- ***Technology Capability and Components***

Navy Taking a Lead Role

Objective Architecture

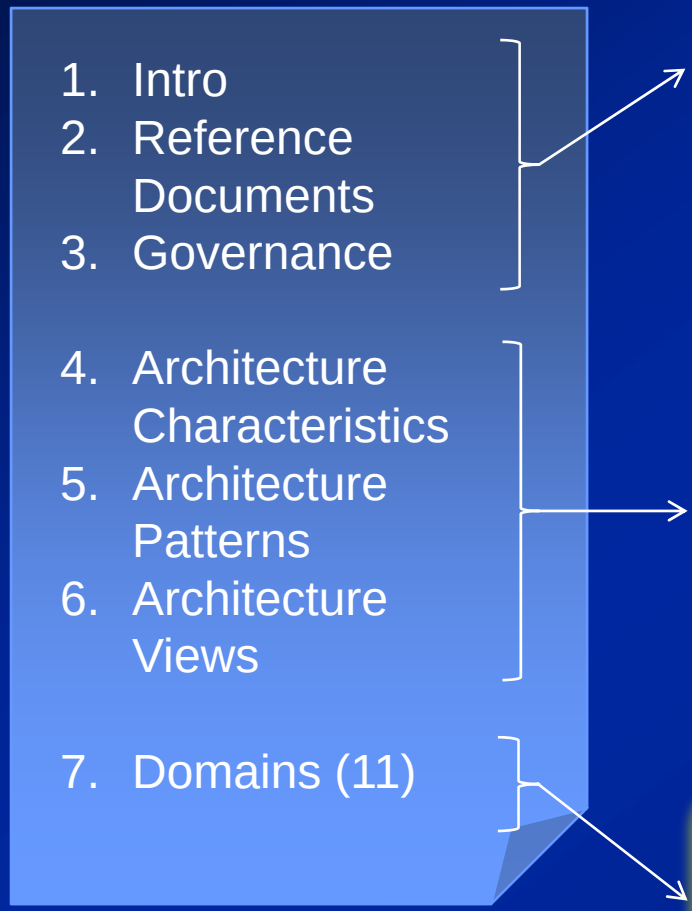
Architectural Context…



- ***Consistent Domains / Boundaries***
- ***Common Precepts and Methods***
- ***Common Functional Allocation***
- ***Common Data Model***
- ***Core Common Components***

Architecture Definition Document Provides "Guidance" for Product/Capability Development

Architecture Description Document



- ***Purpose***
- ***Stakeholders***
- ***Applicable Documents / Efforts***
- ***Architectural Control at Component-Level***

- ***Product-Line Approach***
- ***Component-Based Architecture***
- ***Pub/Sub Messaging / Common Data Model***
- ***Fault Tolerance***
- ***Quality of Service***

- ***Precepts***
- ***Domain-Specific Data Model***
- ***Components***

Top Level Objective Architecture

"Functional View…"

External Communications Domain

Display / User Interface Domain

Vehicle Control Domain

Weapon Mgmt Domain

Sensor Mgmt Domain

Track Mgmt Domain

Command and Control Domain

Support Domain

Ship Control Domain

Training Domain

Infrastructure Domain

Top Level Objective Architecture

"Functional View…"

External Communications Domain

- Provide secure and non-secure voice/data communications
- Perform link management and data forwarding
- Control / monitor comms devices and route data among them
- Report comms status and effective throughput

Display / User Interface Domain

- Display Data (e.g., tracks, tactical situation, operational readiness, …)
- Provide set of common display services and frameworks for applications
- Support variety of display devices
- Display alerts and status
- Process operator actions
- Provide common/consistent GUIs across platforms
- Provide visualization tools

Vehicle Control Domain

- Launch, recover and control manned air vehicles (fixed wing and helo)
- Deconflict airspace / maintain safety of flight
- Control manned small boats
- Control unmanned vehicles (air, surface, undersea)
- Manage links to controlled vehicles

Sensor Mgmt Domain

- Manage and control sensors
- Search/detect objects in background environment
- Transition to track targets
- Report target measurement, track, and attribute data
- Assess and correct measurement errors/biases
- Report sensor status and capabilities

Track Mgmt Domain

- Create System Track File
- Contribute to operational picture
- Determine track ID
- Resolve ID conflicts
- Integrate multiple track data sources
- Perform geodetic registration
- Distribute track data according to need

Command and Control Domain

- Control tactical doctrine
- Evaluate threats
- Evaluate tactical options
- Determine COA
- Plan missions
- Assess mission effectiveness
- Manage resources
- Provide decision aids for operators

Weapon Mgmt Domain

- Process engagement orders
- Compute threat engageability
- Select weapons and schedule engagements
- Initialize/control weapons
- Monitor engagement status
- Monitor/control missiles in flight
- Assess engagement effectiveness/ kill
- Report weapon and engagement status

Support Domain

- Evaluate overall ship readiness
- Provide data to fleet logistics systems and distance support

Ship Control Domain

- Provide precision Nav/Time data
- Generate power / propel ship
- Provide Integrated Bridge and voyage management services
- Monitor and control ship signature characteristics
- Support Damage Assessment and Control
- Control Access to Secure Areas

Infrastructure Domain

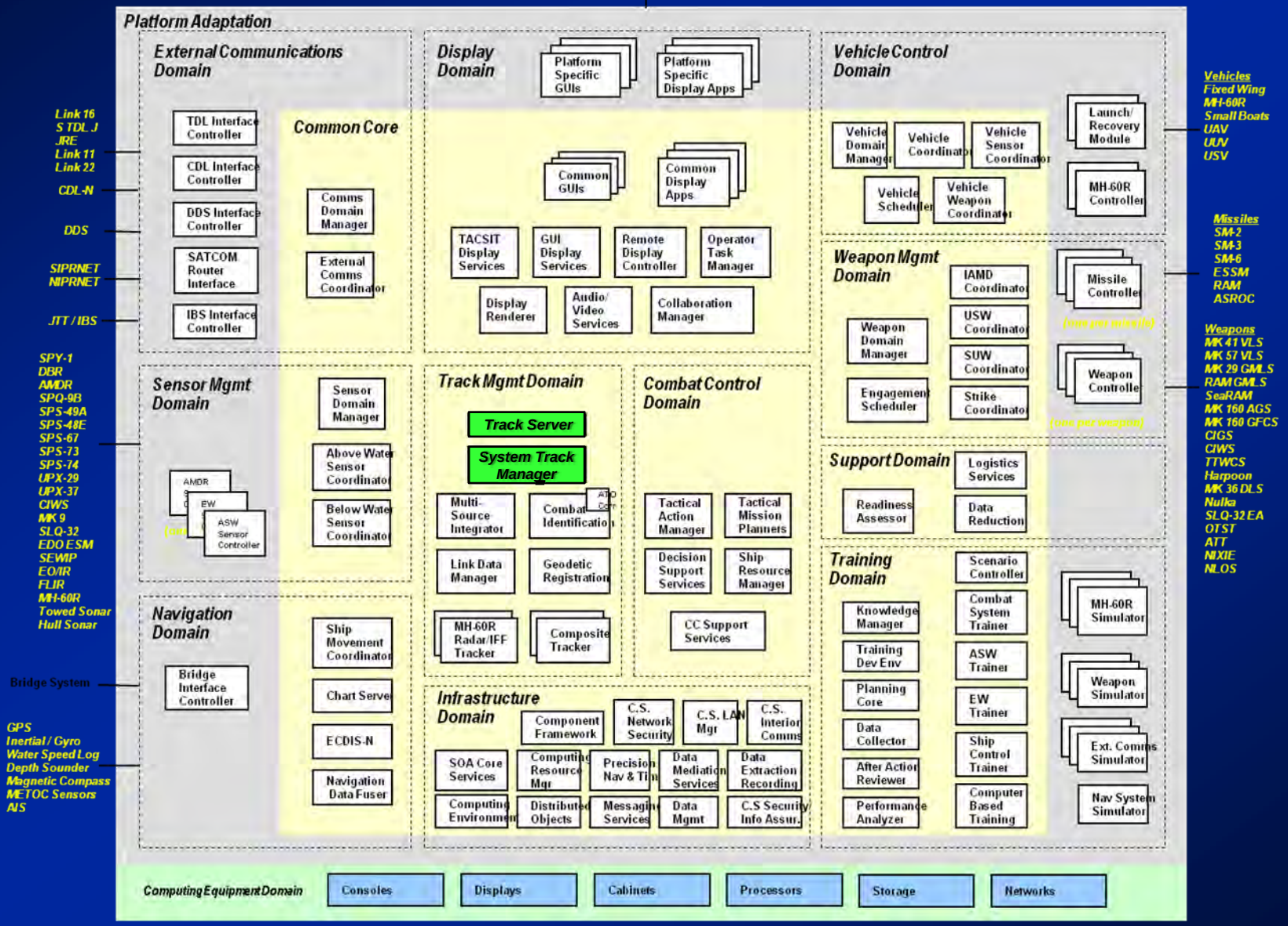
- Provide computing and network services for applications
- Monitor and control computing environment resources and report status

Training Domain

- Provide simulated training environment
- Script and execute training scenarios
- Simulate system inputs IAW scenario
- Control training configuration and events
- Capture training assessment data
- Playback training results and debrief crew
  Provide simulated ship position/movement
- Maintain training record
- Evaluate overall ship readiness
- Provide data to fleet logistics systems and distance support

Top Level Objective Architecture

"Component View…"



Engineering Approach

Engineering Approach

Integrating Product-Line Components into Aegis…

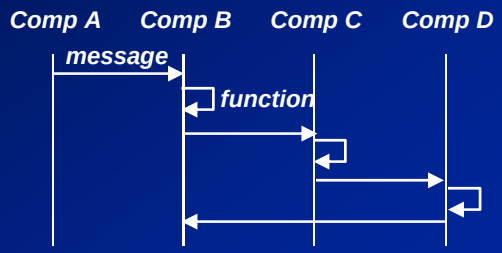
- **Establish Architecture Context:**
  - Adopt Consistent Terminology, Allocation and Boundaries
  - Define Common Core Components – Key Interactions
  - Provide Overall Guidance – Architecture Definition Document (ADD)
- **Normalize Requirements:**
  - Utilize Government-led Working Groups
  - Compare/Contrast System Requirements and Design Approaches
  - Resolve Differences:
    - Establish Common Requirements
    - Establish System-Dependent Behavior
  - Verify Using System Threads
- **Utilize Model-Based Tools/Methodologies:**
  - Define Data Representation (e.g., Structure, Information-Flow)
  - Auto-Generate Code and Specifications/Documents
  - Provide Configurable and Flexible Performance

Data Model is Key

Model Driven Architecture

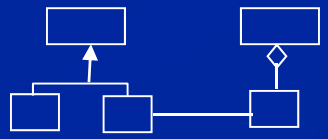
"Defining Components…"

System Threads



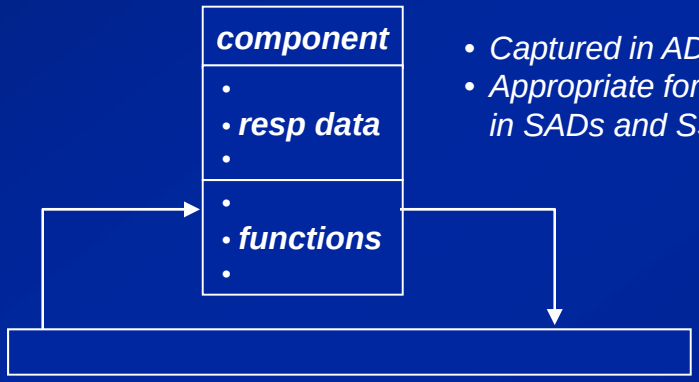
Data Model

Data at Rest
Data in Motion



- *Map legacy data*
- *Normalize it*
- *Bin into messages*

IPO per component

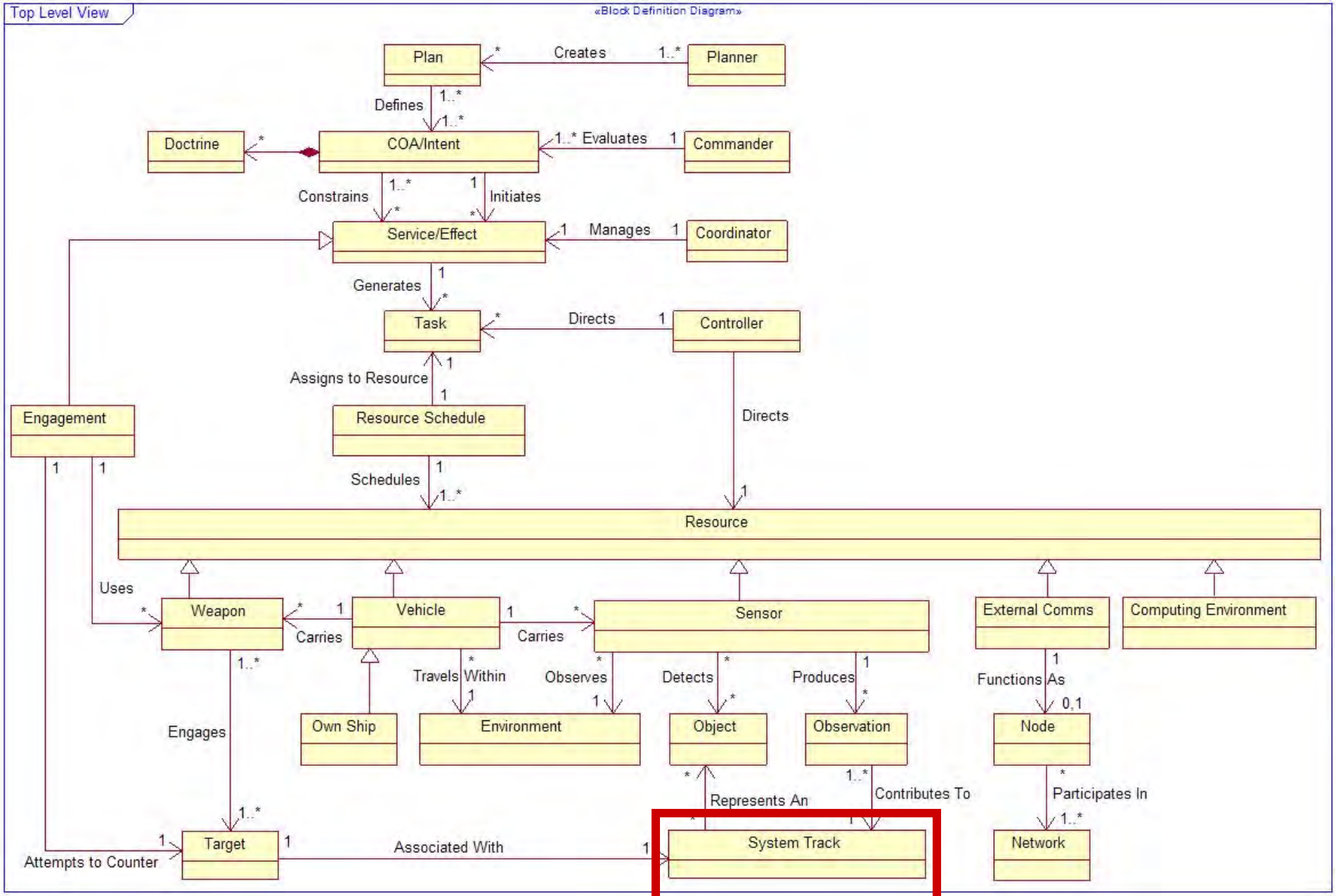


- *Captured in ADD*
- *Appropriate for including in SADs and SSDDs*

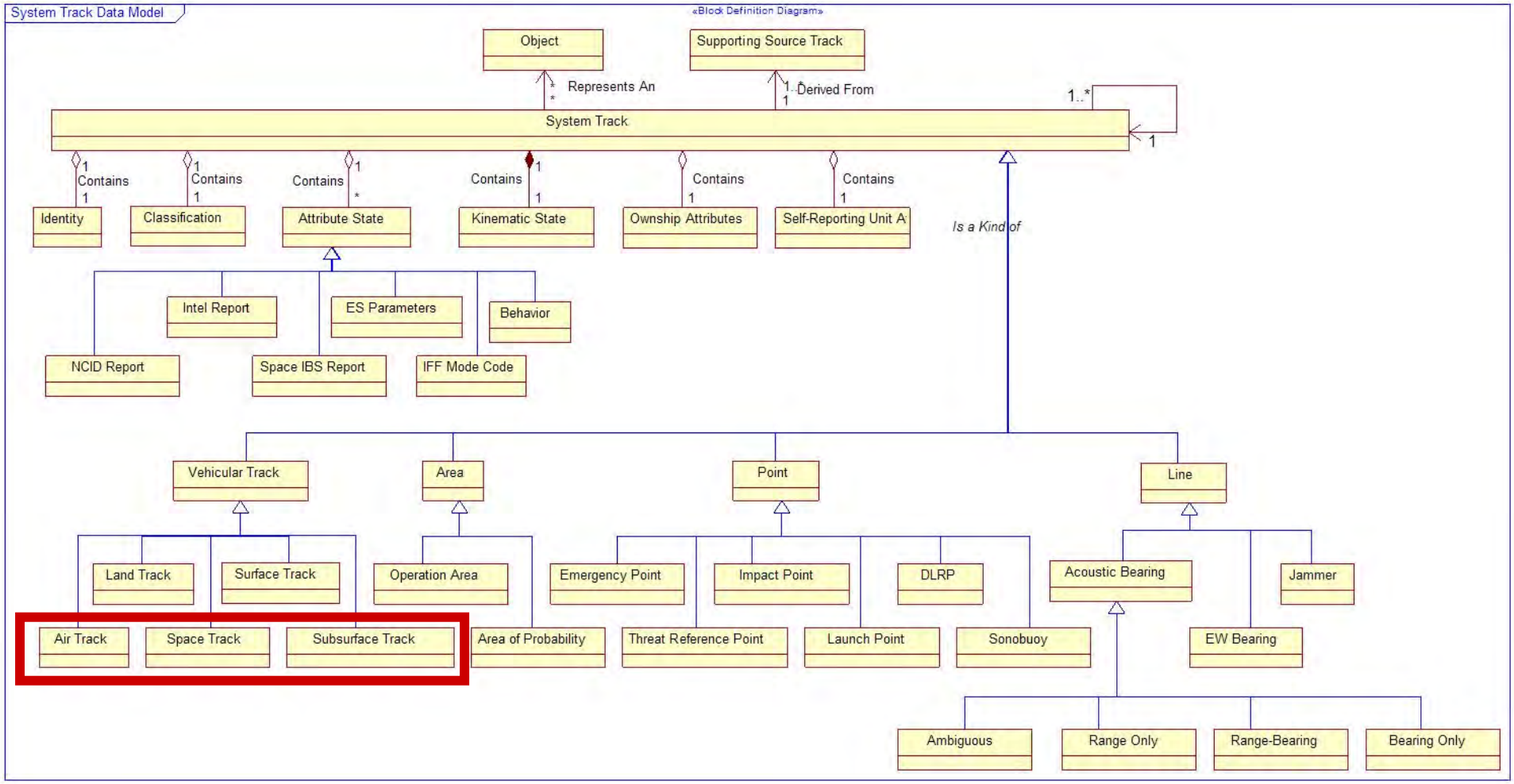
SRS per common component

Applicable legacy requirements
New flowed down requirements

Data Model Overview

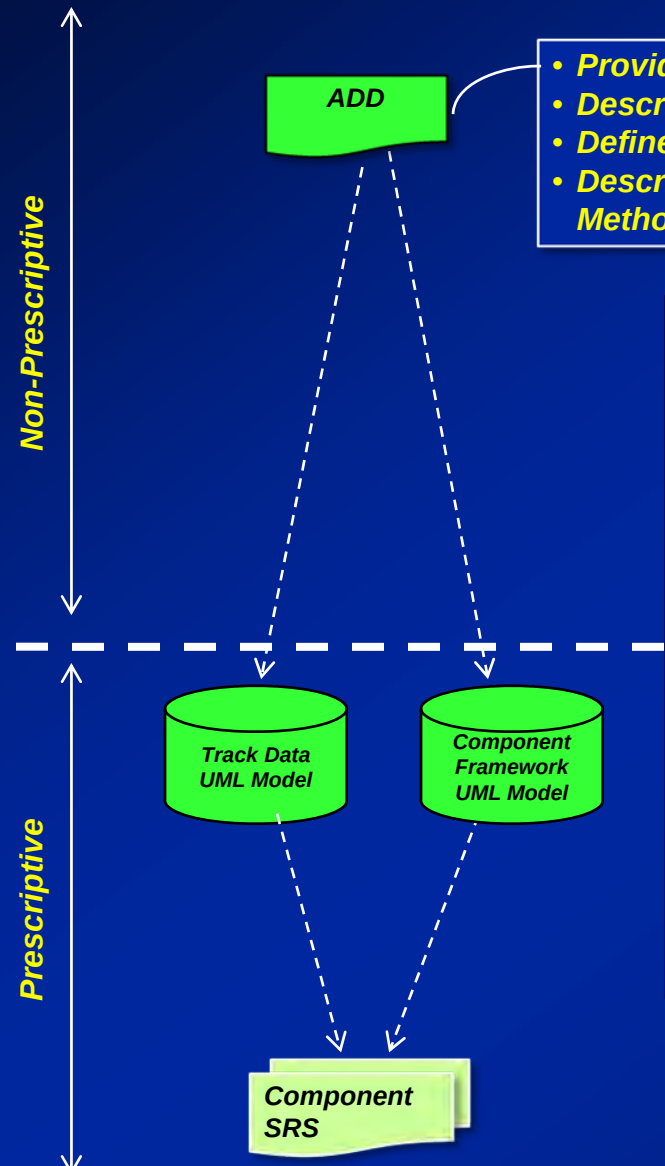


Data Model Overview (cont.)



Model Driven Architecture

"Data Model Definition…"



- ***Provides Lexicon***
- ***Describes Precepts and Desired Qualities***
- ***Defines Boundaries/ Components/ Interfaces***
- ***Describes Optional Techniques and Methodologies***

Conceptual Level

- ***Generalized Data Model(s):***
  - ***Blocks of Information and Relationships***
  - ***Major Attributes and/or Groups***
- ***Major Interaction of Components:***
  - ***Groups of "Flows" – not actual messages***
- ***Significant Library Services / Plug-ins***

SysML

Logical Level

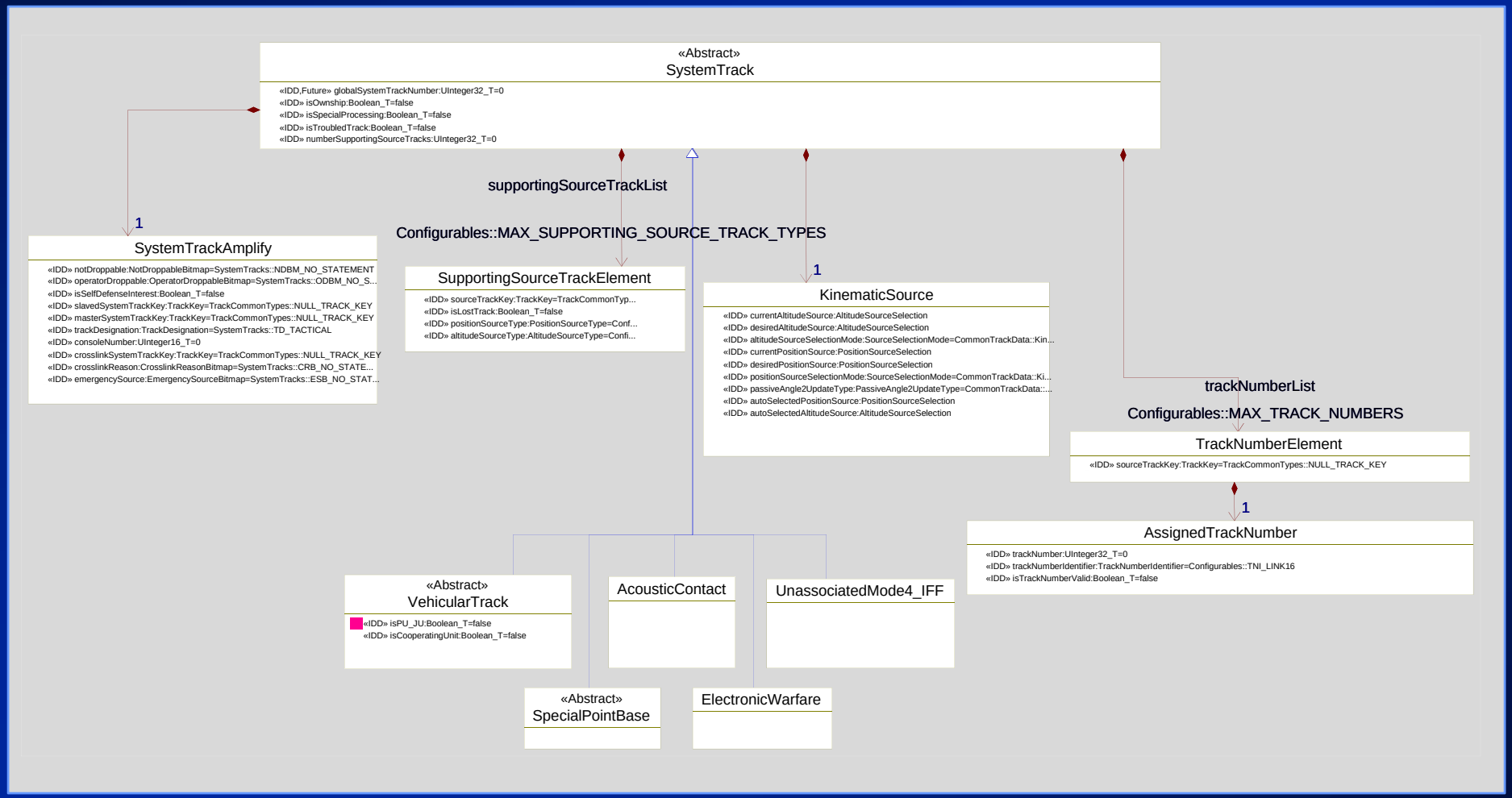
- ***Actual Data Representation:***
  - ***Specific Classes, Attributes and Types (ie "data at rest")***
  - ***Specific Messages/Fields (ie, "data in motion")***
- ***Actual Data and Software Method API's***

- ***Use Cases/Sequence/Activity Diagrams***
- ***Requirements reference messages, notifications, APIs***

UML

Sample Track Attributes

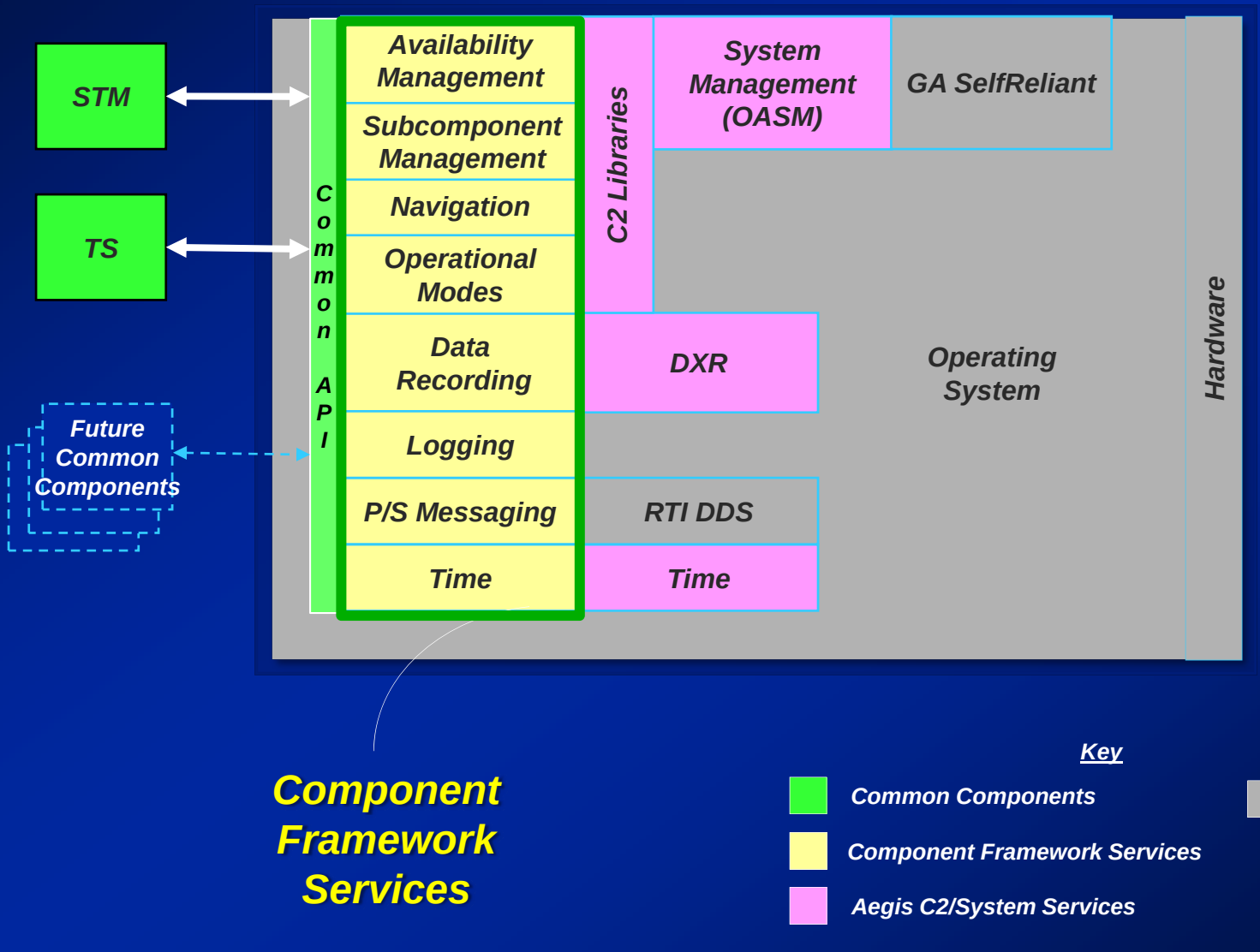
Extracted from track data model…



Sample Track Server APIs

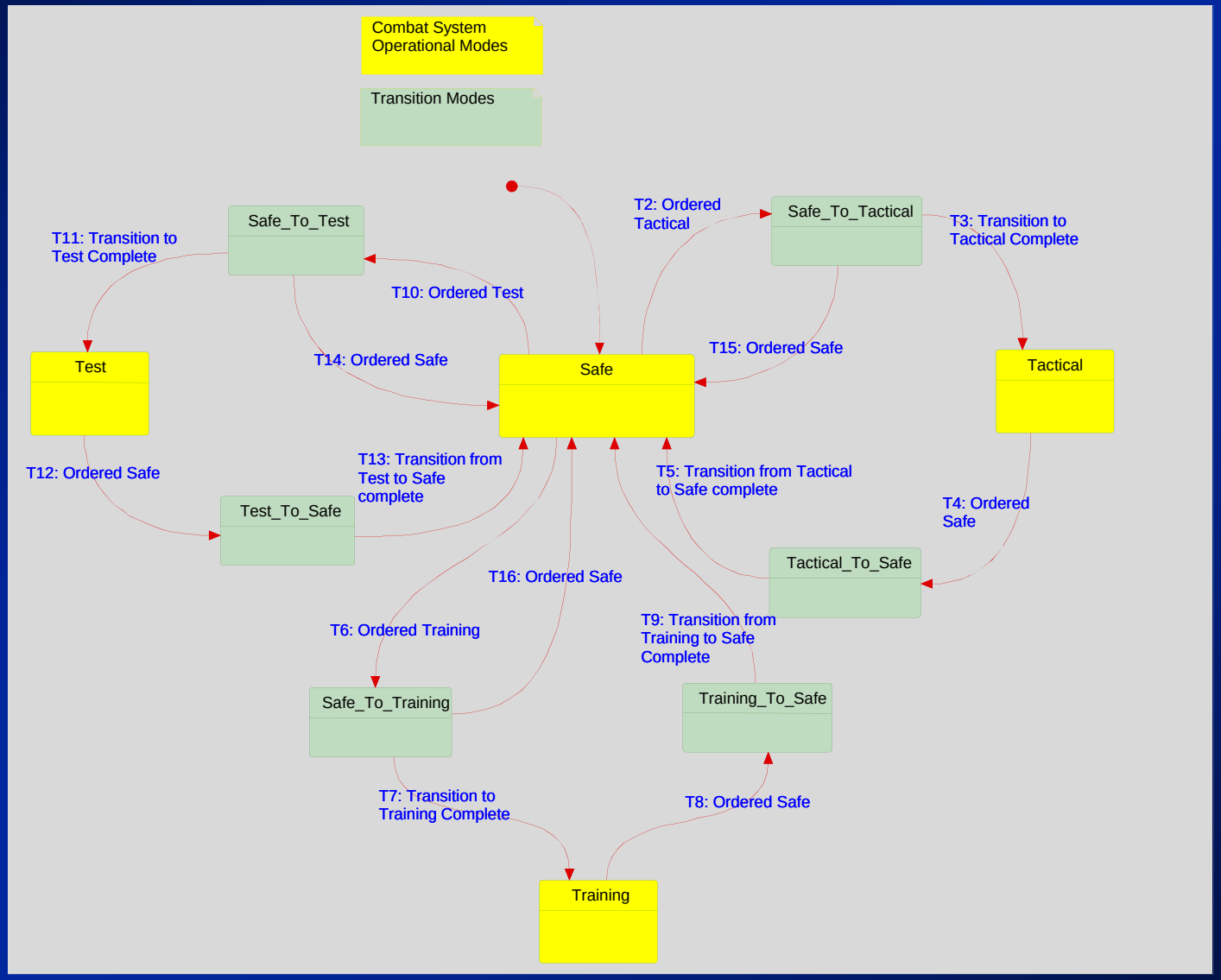
Extracted from track data model…

Component Framework Services



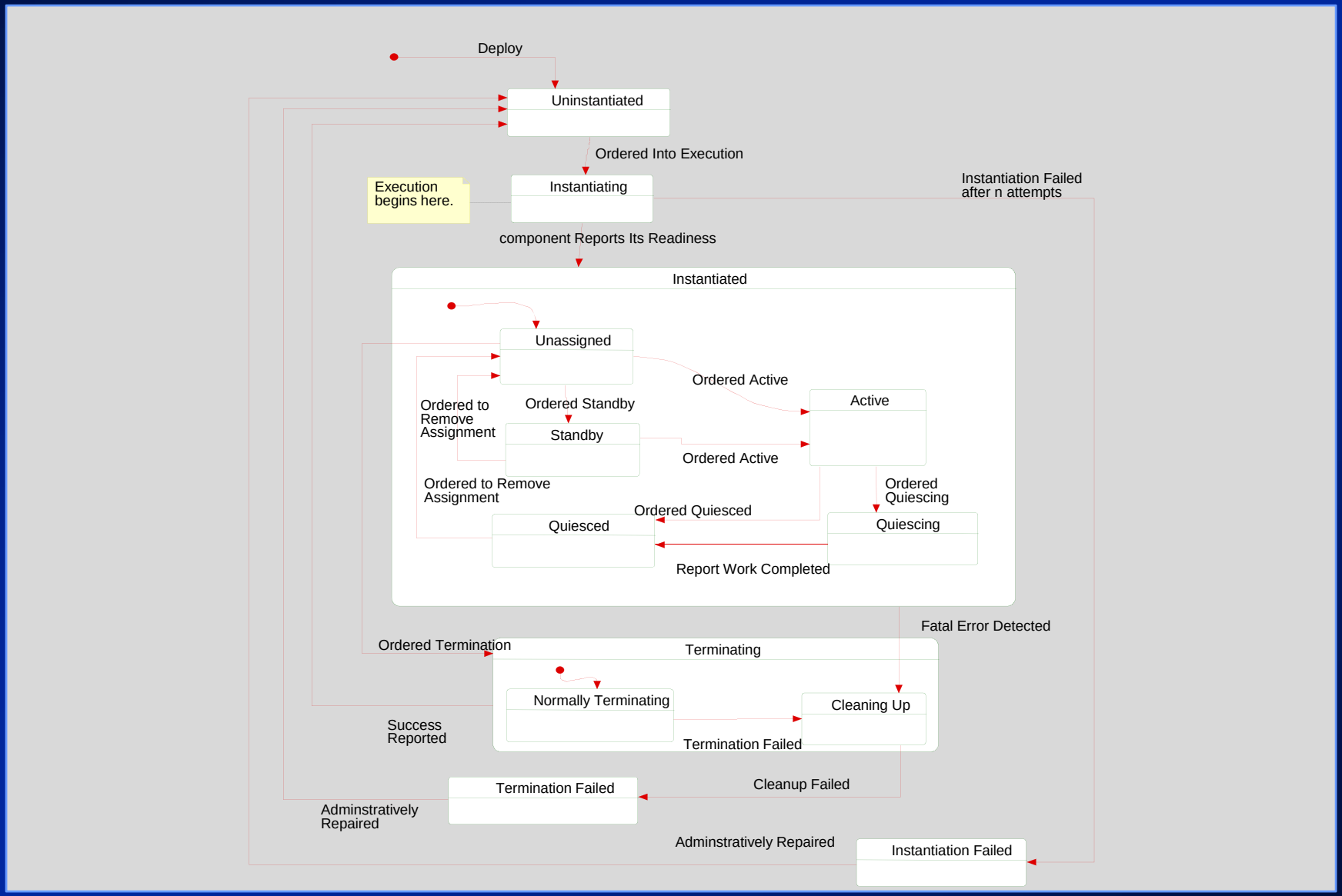
Component Framework

Operational Mode Transitions…



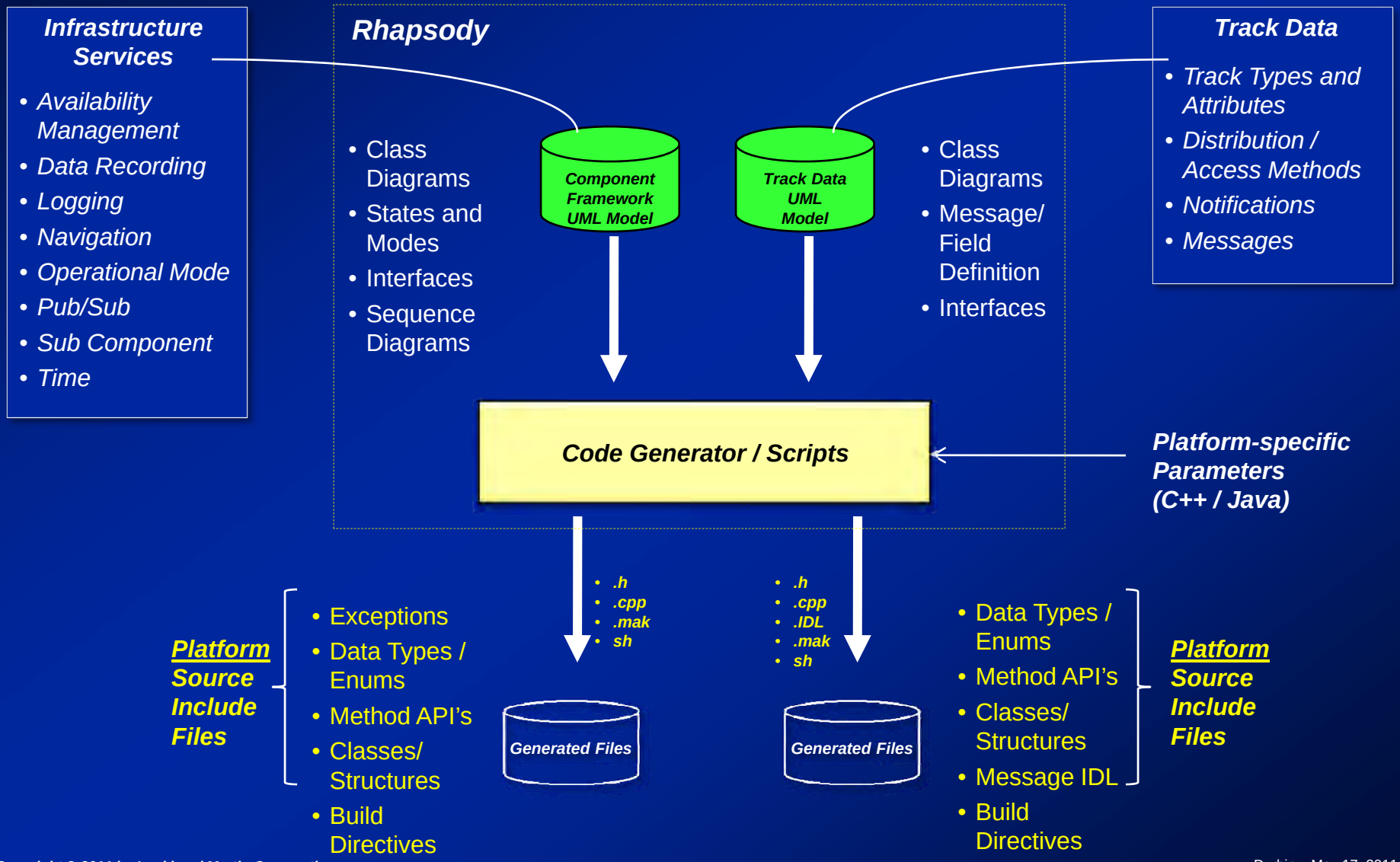
Component Framework

Availability and Presence States…



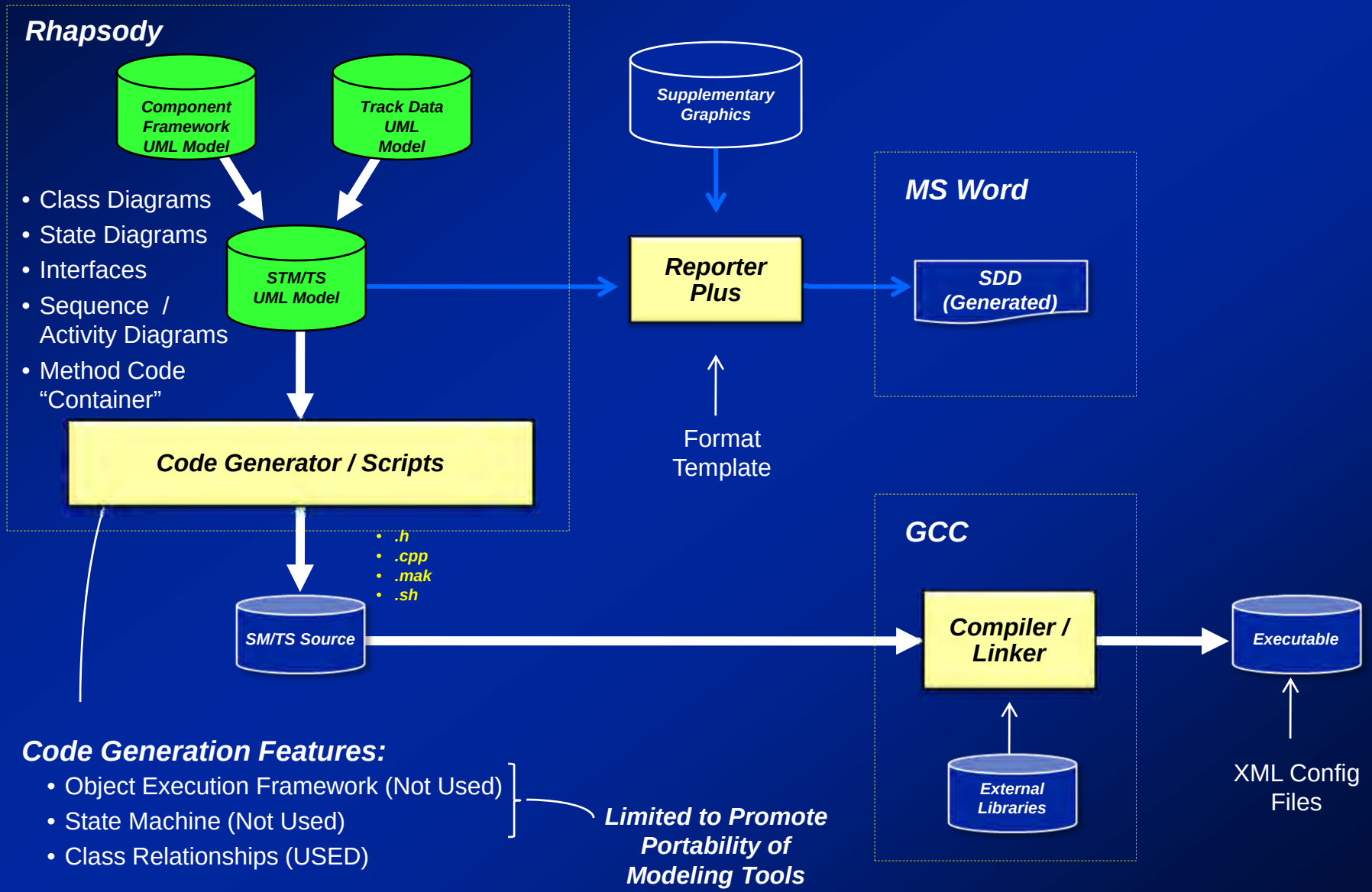
Model Driven Architecture

"Code Generation…"



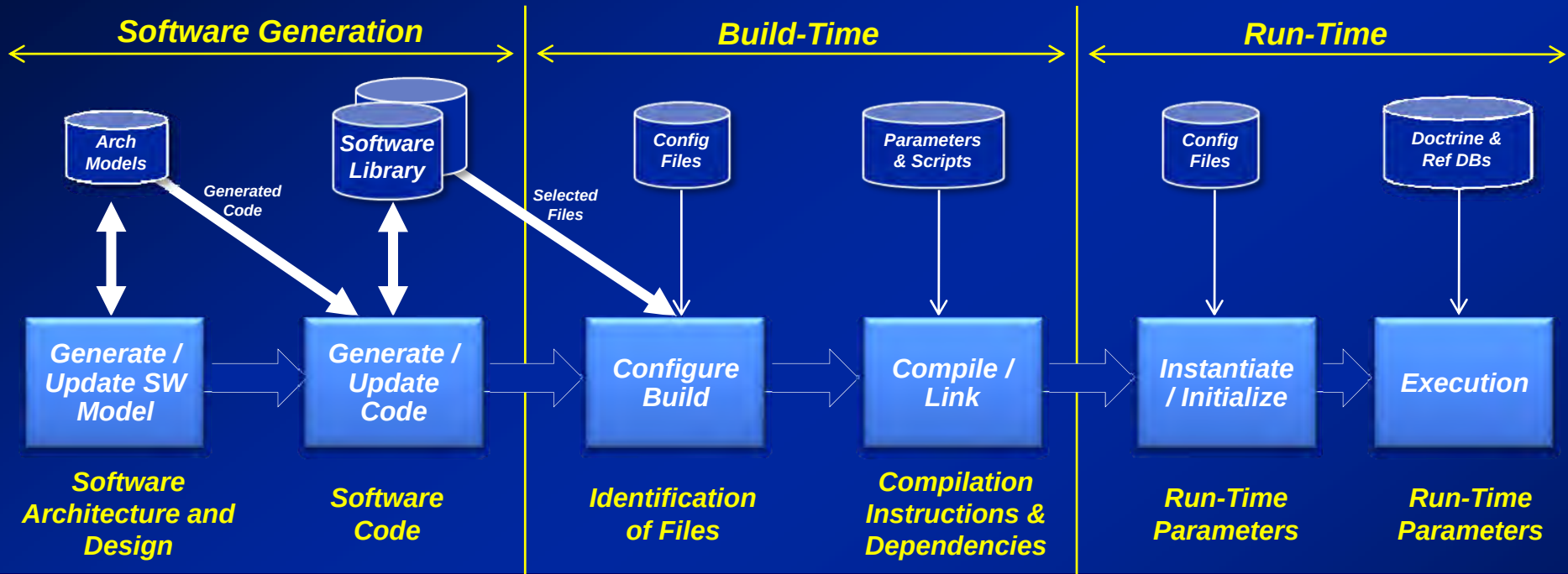
Model Driven Architecture

"Product-Line Component Generation…"



Variation Techniques

Providing flexibility for SW component behavior…



- *Core / Adapt/ Library Services / Plug-in Functional Allocation*
- *Extensible Frameworks*
- *PIM / PSM Separation*
- *Applicability and Version Tags*

- *Model Compile Scripts and Configuration Files*
- *Source Code Compiler Tags*

- *Static Plug-in Binding*
- *Library Services Binding*
- *File Applicability and Version Tags*

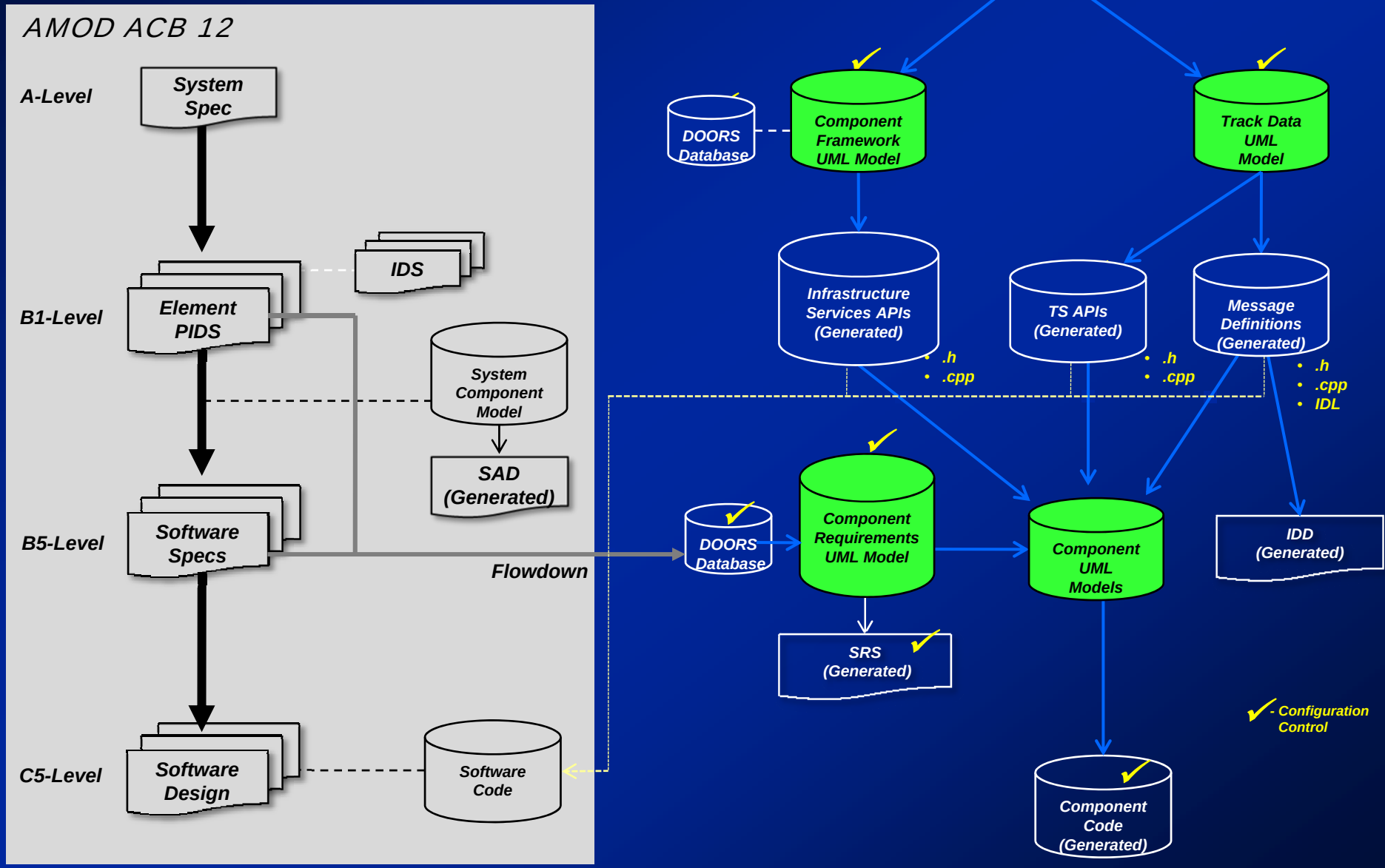
- *Compiler Directives & Scripts*
- *Makefiles*
- *Build Scripts*

- *Site-specific Configuration Files*
- *Platform Adaptation Data*
- *Dynamic Plug-ins*
- *Install Scripts*

- *Dynamic Registration of Services*
- *Untriggered Code Left In Place*
- *Doctrine and Settings / Controls*

Model Driven Architecture

"Putting It All Together…"



Summary

- **Navy Has Followed a Comprehensive Plan Towards Open Architecture**
  - Utilization of COTS Technologies and Products
  - Incorporation of Component-Based Designs
  - Increased Number of Players/Opportunities
- **Product Line Approach Established to Facilitate Combat System Alignment**
  - Government Owned Architecture and Authenticated Interfaces
  - High-Level Acquisition Strategy
  - Robust Reference (aka Objective) Architecture
- **Model-Driven Tools/Methodologies Have Been Used Effectively**
  - Data Model Representation of Information Structure and Flow
  - Auto-Generation of Code and Specifications/Documents
  - Initial Common Components Have Been Successfully Integrated into Aegis Baseline 9

Glossary

Acronym	Description	Acronym	Description
ACB08	Advanced Capability Baseline 2008	**LAN**	Local Area Network
ACB12	Advanced Capability Baseline 2012	**LM**	Lockheed Martin
ACS	Aegis Combat System	**LOT**	Launch on TADIL
ADD	Architecture Definition Document	**MMSP**	Multi-Mission Signal Processor
Aegis	(not an acronym) Greek Shield of Zeus	**MS**	MicroSoft
ALIS	Aegis LAN Interconnect System	**NIFC-CA**	Naval Integrated Fire Control - Counter Air
AMOD	Aegis MODernization	**OA**	Open Architecture
API	Application Programming Interface	**OAET**	Open Architecture Enterprise Team
ASCM	Anti-Ship Cruise Missile	**OASM**	Open Architecture System Management
ASROC	Anti-Submarine ROCket	**P/S**	Publish/Subscribe
BL	Baseline	**PIDS**	Prime Item Development Specification
BMD	Ballistic Missile Defense	**PIM**	Platform Independent Model
C2	Command and Control	**PSEA**	Platform System Engineering Agent
CCB	Configuration Control Board	**PSM**	Platform Specific Model
CEC	Cooperative Engagement Capability	**Pub/Sub**	Publish/Subscribe
CG	Guided Missile Cruisers	**RF**	Radio Frequency
CIWS	Close In Weapon System	**SAD**	System Architecture Document
CM	Configuration Management	**SAN**	Storage Area Network
COTS	Commercial Off-the-Shelf	**SBT**	Sea-Based Terminal
CPCR	Computer Program Change Request	**SI/DA**	System Integrator / Design Agent
CR	COTS Refresh	**SM**	Standard Missile
CSEA	Combat System Engineering Agent	**SMP**	Symmetric MultiProcessor
CVN	Carrier Vessel Nuclear	**SQT**	System Qualification Test
DDG	Guided Missile Destroyer	**SRS**	System Requirements Specification
DDS	Data Distribution Service	**SSDD**	System/Segment Design Document
DM	Data Model	**SSDS**	Ship Self Defense System
DOORS	Dynamic Object-Oriented Requirements System	**SSR**	Software Specification Review
ESSM	Evolved Sea Sparrow Missile	**STM**	System Track Manager
ETR	Engineering Technical Review	**SVC**	Service
GCC	GNU Compiler	**SW**	Software
GFE	Government Furnished Equipment	**SysML**	Systems Modeling Language
HM&E	Hull, Mechanical and Electrical	**T&E**	Test and Evaluation
HW	Hardware	**TADIL**	TActical Digital Information Link
IAW	In Accordance With	**TI**	Technology Insertion
IDD	Interface Definition Document	**TLAM**	Tomahawk Land-Attack Missile
IDS	Interface Design Specification	**TOR**	Test Observation Report
IMS	Integrated Master Schedule	**TS**	Track Server
IPO	Input/Output/Process	**UML**	Unified Modeling Language
IR	Infrared	**VLA**	Vertical Launch ASROC
JTM	Joint Track Management	**VLS**	Vertical Launch System
KA	Kill Assessment	**XML**	eXtensible Markup Language